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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
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Feeder verification with a camera

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Feeder verification with a camera

Feeder verification with a camera

Field of the Invention

The present invention relates to the monitoring the configuration of component feeders on a component placement machine, for example for electronic components.

Background of the Invention

For electronic board assembly, automated component placement can reach very high speed up to tens of thousands of surface mounts of components per hour. These components are typically supplied by component vendors as taped reels of components that are loaded onto individual feeders which are mounted in corresponding feeder slots on the machine. These reels of components may be loaded onto the feeders at a special loading unit, for example in a stock room, after which the loaded feeders are placed in the feeder slots.

Component placement machines can have more than 100 feeder slots each accessible by a picking mechanism that picks individual components from the feeders in the slots and places them in particular predetermined locations on a printed circuit board. For application flexibility, each feeder and slot is generally constructed to be compatible with many different components.

The physical arrangement of components, feeders and slots must be in accordance with the expected arrangement as programmed in the machine. Any error in the arrangement can cause a corresponding error in the placement of components on the board. In a high volume, low mix manufacturing environment, a component loading error can produce a high number of defective printed circuit boards in a short period of time. In a low volume, high mix environment the chance of component loading error increases because of frequent feeder manipulation for product change over.

In order to eliminate loading errors, it is known to place bar code labels on individual feeders and slots for manual scanning to control that the right components indeed are placed in the right slots according to a so called device list, which contains a listing of the slots and the components that are expected in the different slots. This procedure is carried out, before the machine begins its operation.

Often, component placement machines are not born with sufficient control mechanisms to assure the feeding of correct components as desired by the user of these types of machines. Different solutions have been suggested where additional equipment is provided from a producer different than the producer of the machine and postmounted on the machine. For such postmounting, certain conditions in connection with the machines, as the mechanical structure, have to be taken into account. Often, the task is not to find the optimum solution generally, but to find the optimum solution under the given circumstances, that is to say to find the optimum solution for a given mechanical structure of the component placement machine. For example, some component placement machines have feeders on a table that moves with respect to the pick-up system while others have a stationary table and a moving pick-up system. The control solutions are typically different for these two different types of machines.

A postmounted control system has been disclosed in US patent no. 6 027 019. In this system, two scanners are adapted to monitor the arrangement of slot markers and feeder markers in the machine while the machine is in operation. The slot marker and feeder marker are then compared with data in a device list. Such a control system is only applicable for existing machines, where the table is moveable while the pick up is stationary. In existing machines with movable pick-up systems, not enough space is left on the pick up for mounting a scanner on the pick-up.

This system as described in US patent no. 6 027 019 has another disadvantage in not being able to detect feeders with wrong components before the machine is started. An eventual error is first detected, after the first component has been picked up. If a component is wrong, expensive time is wasted until the machine is stopped and rearranged.

For machines with stationary feeder tables, a system is known, where each feeder is equipped with a transponder that is connected with the feeder by a chain. The transponder is inserted in a corresponding array table behind the feeder for manual check whether the feeder is in the right slot. However, also this system has a drawback in not being able to prevent a misplacement of the transponder. The latter is due to the fact that feeders may be rather slim with the result of a hardly discernible correct position of two adjacent feeder positions in the table.

For existing machines, no control solution has hitherto been proposed for taking into account the situation of the so-called splicing when a feeder only has a few components left on a tape. During splicing, the empty reel is taken out of the feeder without removing the remaining few components on the tape in the feeder. The tape with the remaining few components is then fastened - spliced - to a new tape with components rolled on a new reel, which then is inserted into the feeder. The advantage is that reels can be exchanged without having to exchange the feeder or stop the operation of the machine. However, no system has hitherto been provided to control whether a tape with correct components has been spliced to the tape with the remaining few components.

Summary of the Invention

It is the purpose of the invention to provide a method for monitoring the configuration of component feeders on a component placement machine, which is independent of whether the machine has a movable table or a moveable pick-up. Advantageously the invention shall also be extendable to take into account the situation of splicing.

This purpose is achieved by a method for component verification during operation of a component placement machine having a series of feeder slots for holding component feeders with feeder markers, each feeder marker carrying a unique feeder ID, wherein each feeder slot has a unique slot ID, wherein the method comprises providing at least one camera for providing an image of said series of feeder slots, performing image analysis on said image for determining the actual feeder IDs of the actually installed

feeders in said series of feeder slots, determining from stored configuration information the intended feeder IDs of those feeders that are intended to be installed in said series of feeder slots, and checking by comparing the actual feeder IDs with the intended feeder IDs whether the actually installed feeders in the feeder slots correspond to the intended feeders.

The *intended* feeder ID refers to the expected feeder to be found in the actual slot according to stored configuration information, while the *actual* feeder ID refers to the feeder which actually is in the actual slot. These two IDs are compared, and in case of discrepancy between the intended feeder ID and the actual feeder ID, the discrepancy may be indicated, for example by an alert to the operator of the machine, or stored and evaluated by other means.

Whilst the feeder ID is actually indicated on the feeder and used for reading, the slot ID need not be indicated on the slot itself. However, the slot ID is unique and stored in a database as an address for component pick-up for the corresponding slot.

The method according to the invention has a number of advantages. The method according to the invention may be implemented on existing placement machines, which is an important criterion. A camera may be installed stationary at an appropriate location with optics that image the feeder slots with a suitable resolution. The camera type may be a CCD (charge coupled device) camera with a single chip. Alternatively, a number of cameras may be used, where an image for analysis is produced as a combined image from the images from this number of cameras. Such image addition is known according to prior art in different application fields.

The additional equipment necessary for a system where the method according to the invention may be implemented is cheap, and implies mainly one or several low cost cameras, some cabling, a computer and an image analysis program. Therefore, such a system is highly attractive.

One of the great advantages of the method according to the invention is the control of feeders before the machine starts operating. This prevents placement of wrong components during operation of the machine and, therefore, indirectly saves time and money. Also, the avoidance of manual checking procedures avoids mistakes by operators and therefore reduces machine stopping during operation.

Another advantage is the fact that the method according to the invention is applicable for several types of machines. It may be applied with machines, where the feeder slots are mounted on a stationary table and where the components are picked-up by a moving pick-up. It may also be applied for machines, where the pick-up is stationary and where the table with the feeder slots is displaceable.

A practical approach is given in the following. In connection with the image of the series of feeder slots, a series of position coordinates is provided, where each position coordinate is associated to a slot ID of a feeder slots in this series of feeder slots. These position coordinates may be given for all slots or only for those slots where feeders are installed and used for the component pick-up. By performing image analysis on the obtained image, the actual feeder IDs of the actually installed feeders in said series of feeder slots are determined and an actual position coordinate is assigned to each of these actual feeder IDs. Such an actual position coordinate is taken from the series of position coordinates. From stored configuration information, typically the Device List and the Feeder/Component List, the intended feeder IDs are determined of those feeders that are intended to be installed in said series of feeder slots. Furthermore, for each of those intended feeders, an intended position coordinate is determined, which also is taken from the series of position coordinates. Then, for each intended position coordinate, it is checked whether an actual feeder ID is assigned to the position, and if this is not the case, this is indicated, for example by an alarm message to the operator of the machine. If on the other hand this is the case, it is checked whether the intended feeder ID and the actual feeder ID for this position coordinate are equal, and if this is not the case, this discrepancy is indicated, for example by an alert to the operator.

The aforementioned Feeder/Component List associates each intended feeder ID with a component ID indicative of the type of component to be contained in the corresponding feeder. The mentioned Device List associates feeder slots with component IDs. These data lists are normally available for the machine, as these lists are used in the programmed operation of the machine.

Instead of comparing the intended ID of the intended feeders in said series of slots with the imaged actual feeder ID's, an alternative embodiment may be used, which is in principle equivalent though in practice slightly different. This alternative embodiment is a method for component verification during operation of a component placement machine having a series of feeder slots for holding component feeders with feeder markers, each feeder marker carrying a unique feeder ID, wherein each feeder slot has a unique slot ID. This method comprises providing at least one camera for providing an image of said series of feeder slots and performing image analysis on said image for determining the actual feeder IDs of the actually installed feeders in said series of feeder slots. For each actual feeder, the first component ID for the type of components contained in said actual feeder is determined from stored configuration information, where said stored configuration information comprises a first list associating each intended feeder ID with a component ID indicative of the type of component to be contained in the corresponding feeder. For each slot defined to contain a feeder, the second component ID for the component that is supposed to be contained in said feeder is determined from stored configuration information, where said stored configuration information comprises a second list associating feeder slots with component IDs. As a final step, it is checked whether the first and the second component ID are equal, and if this is not the case, this discrepancy is indicated.

Measuring distances and assigning coordinates to the slots and feeders can be used for a further improvement of the invention. In this case, the feeder type may be identified, for example by measuring the width of the feeder. This feature further reduces the risk for faults.

In order to associate the position coordinates to the slot ID of each feeder slot, the following procedure is employed in a further embodiment of the invention, where the slot distance between adjacent slots in the series of feeder slots is assumed constant. For each particular feeder slot, the number of slots from the first slot to the particular feeder slot is determined. To the position coordinate of the first slot coordinates are added that are equivalent to the distance from the first slot to the particular feeder slot. This distance is calculated as the slot distance between adjacent slots times the number of slots from the first slot to the particular feeder slot. This is a very simple procedure which is fast and safe.

In certain types of machines, the feeder slots are mounted on a displaceable table with a rest position or start position. In this case, position coordinates may be associated to the slot ID by using an image which is taken in the rest position or start position of said table.

In order to assure that the images taken are evaluated correctly, the following procedure may be implemented in the method according to the invention. For associating position coordinates to the slot ID, a position mark is provided with a certain fixed distance to the series of feeder slots. This position mark is imaged together with the series of feeder slots and the position coordinates are calculated in relation to the position mark. The value of this additional step may be found in the following. During operation, the camera may be exposed to dust, such that the image analysis program may not function properly any more. For example, the first slot may not be determinable with certainty. Such a difficulty may also arise in case that the camera has been moved accidentally. Furthermore, the table may be of the movable type, where the rest position or start position of the table is not well defined or sufficient accurate. In these cases, it is of advantage that the image analysis program has to recognize a position mark. If this position mark is recognized, the coordinates of the slots with feeders may be calculated.

In order to generally assure that the camera works properly, for example to assure that the CCD chip or the objective have not been subject to damage or that the cabling or

image processing program work properly, an image control is preferably performed automatically for determining the performance of the camera. For example such a control may be performed routinely before every production process when the machine is stopped. Such a control may advantageously be combined with the aforementioned position mark.

The following embodiment of the invention takes into account the situation of splicing in certain placement machines. Splicing is performed manually which, due to human error, may result in final products having defects because wrong component reels have been spliced and packed into the feeder. In order to trace the wrong components from the wrong spliced reel, the invention foresees the following further embodiment. The splicing may be performed by incorporating a label, for example a colored or patterned band behind the components, at the splicing region of the component reel in a feeder. The label is then recognized by the image analysis system and the date and time for the use of components from a spliced reel may be stored in a database. If a defect product is found at a later stage and the quality control reveals a wrong component, the stored date and time data help finding other defect products.

In fact, the image system with the camera and the image analysis program may be configured with such a resolution and precision that the components to be picked-up from the feeders may be recognized by the image analysis system for determination whether the components from a feeder in a feeder slot correspond to components intended to be taken from that feeder. In this case, a splicing of reels with wrong components may be recognized early and the production of defect products prevented.

The pitch of the reel in a feeder is adjustable. For example, the distance of the components to be picked-up from the reel in the feeder may be 4 mm. If the pitch in the feeder is 8 mm, only every second component is picked-up from the reel. Such a mistake is hard to recognize by the operator, because the production process itself works correctly, just every second component is wasted. The method according to the invention with the image system is taking account for this problem in a further embodiment, where the obtained image is analyzed for recognition of the correct reel pitch. In case

that the recognized reel pitch is not in accordance with stored configuration information, an alert is given to the operator.

Furthermore, the image analysis program may as well be configured to recoguize defect feeders installed in feeder slots.

Brief Description of the Drawings

The invention will be explained in more detail with reference to the drawing, where

FIG. 1 shows the principle of a placement machine post-equipped with a camera,

FIG. 2 illustrates the method according to the invention,

FIG. 3 illustrates an alternative embodiment.

Description of preferred embodiment

In FIG. 1, a placement machine 101 is illustrated having a platform 102, on which a number of slots 103 are located. Into each slot 103, a feeder 104 may be placed. Certain feeder 104 types may extend into several slots 103. The platform 102 is displaced relatively to the component pick up arm 105 for picking up components from different slots 103. Alternatively, the pick up arm 105 may be displaced with respect to the platform 102.

Each feeder 104 is provided with an identification marker, for example a bar code label, which is designed to be readable by an appropriate scanner. According to the invention, the feeder marker is imaged by a camera 107 and analyzed in a computer 108 by a image analysis computer program. By using a camera 107 according to the invention, the feeder marker may be different from a bar-code.

The camera 107 images the series of slots 103 with feeders on the table 102. The camera 107 may be equipped with an objective 109 with a view 110 that covers the complete table 102. Alternatively to cover a long table, a number of cameras 107 may be

used to take images which then are combined by appropriate computer routines in the computer 108.

For stationary tables 102, the camera may be mounted at a fixed position. For moving tables, the camera may move along with the table or the camera 107 and the image analysis program may be programmed only to evaluate images, when the table 102 is in a special position, for example the start position. For additional precision and convenience, a position mark 111 may be provided with a fixed distance to the slots 103, for example by providing such a rigidly connected to the table. In the latter case, the table needs not to have a certain position for the imaging, as the position mark may have the role for coordinate calibration for the slots. Alternatively, the mark may be positioned independently of the table. In case of a moving table, the distance is not fixed but nevertheless well defined when the table is in the rest or start position.

Normally, when component reels are loaded into a feeder 104, the feeder marker is read and the feeder ID 203 is stored in a first list together with the first component ID 204' of the component reel in the feeder 104. The computer 108 is configured to have access to these data in a list, which is illustrated in FIG 2 as a feeder/component list 201. From other stored configuration information, a second list shown as a device list 207, a second component ID 204 of the type of component expected in a slot with slot ID 208 may be found. Combining the data from these two lists 201, 207, the intended feeder with intended feeder ID 203 - Feed N - in a certain feeder slot 208 may be found 212. Not all slots 103 may contain a feeder 104, as not all slots 103 may have to be used in a production process.

In the computer program performing the method according to the invention, the intended feeder ID 203 in each feeder containing slot is checked against the actual feeder ID that may be read by the camera for each particular slot. For this, the camera 107 images 202 the table 102, where each slot ID 208 is provided with position coordinates. This is preferably done for all slots, such that a series of position coordinates is obtained for the whole series of slots, but it may, alternatively, only be done for those slots that are intended to contain feeders 103. The first slot is found automati-

cally by the image analysis 205, for example by using the position mark 111, and a coordinate is assigned to this first slot. In case that the distance between adjacent slots is constant for all slots, the distance to the following slots can easily be found by multiplication or addition and corresponding coordinates can be applied. If the distance between slots 103 is not constant, the image analysis program can be programmed to find the slots 103 automatically and then assign appropriate position coordinates to the slots as determined from the image.

From the lists 201, 207 as described above, those slots that contain feeders are evaluated further in that it is checked 206 whether a feeder is contained in theses slots at all. If this is not the case, an alert 209 is given to the operator. From the obtained image, the actual feeder marker is read and the actual feeder ID - Feed N' - determined 210. In a next step, the intended feeder ID - Feed N - and the actual feeder ID - Feed N' - are compared 211 and in case of non-compliance, an alert 209 is given to the operator.

Instead of comparing 211 the intended ID 203 of the intended feeders in said series of slots 208 with the imaged actual feeder IDs 210, an alternative embodiment may be used, which is in principle equivalent though in practice slightly different. In FIG. 3, this alternative approach is illustrated. From the obtained image 202 which is analyzed 205, the actual feeders 104 in the slots 103 are determined 210. In this embodiment, the first component ID 204' for the type of components contained in said actual feeder 203 is determined from the device list 201. For each slot defined to contain a feeder, the second component ID 204 for the component that is supposed to be contained in said slot is determined from the device list 207. As a final step, it is checked whether the first and the second component ID are equal, and if this is not the case, this discrepancy is indicated 209.

The alert 209 to the operator may alternatively be coupled to an automatic stopping routine of the machine such that the control and the action after a recognized fault may prevent any placement of components. The method according to the invention may be implemented to only function before the placement machine starts operating. It may

also be implemented such that the method is performed steadily during the operation of the placement machine in order to achieve maximum security.

CLAIMS

1. Method for component verification during operation of a component placement machine (101) having a series of feeder slots (103) for holding component feeders (104) with feeder markers, each feeder marker carrying a unique feeder ID, wherein each feeder slot (103) has a unique slot ID (208),

characterised in that the method comprises

- providing at least one camera (107) for providing an image (202) of said series of feeder slots (207),
- performing image analysis (205) on said image for determining (210) the actual feeder IDs of the actually installed feeders (114) in said series of feeder slots (103),
- determining (212) from stored configuration (201, 207) information the intended feeder IDs (203) of those feeders (104) that are intended to be installed in said series of feeder slots (103),
- checking by comparing (211) the actual feeder IDs with the intended feeder IDs (203) whether the actually installed feeders in the feeder slots correspond to the intended feeders.

2. Method according to claim 1, wherein the method comprises

- in connection with said image providing a series of position coordinates, where each position coordinate is associated to a slot ID (208) of a feeder slot (103) in said series of feeder slots,
- performing image analysis (205) on said image for determining (210) the actual feeder IDs of the actually installed feeders (104) in said series of feeder slots and assigning an actual position coordinate to each of these actual feeder IDs, said actual position coordinate taken from said series of position coordinates,
- determining (212) from stored configuration information the intended feeder IDs (203) of those feeders that are intended to be installed in said series of feeder slots and determining for each of those intended feeders an intended position coordinate, said intended position coordinate taken from said series of position coordinates,

- checking (206) for each intended position coordinate, whether an actual feeder ID is assigned to said position, and indicating (209) if this is not the case, and if this is the case,

- checking (211) whether the intended feeder ID and the actual feeder ID for this position coordinate is equal, and if this is not the case, indicating (209) this discrepancy.

3. Method according to claim 1 or 2, wherein said stored configuration information comprises

- a first list (201) associating each intended feeder ID with a component ID (204') indicative of the type of component to be contained in the corresponding feeder (203), and

- a second list (207) associating feeder slots IDs (208) with component IDs (204).

4. Method for component verification during operation of a component placement machine (101) having a series of feeder slots (103) for holding component feeders (104) with feeder markers, each feeder marker carrying a unique feeder ID, wherein each feeder slot (103) has a unique slot ID (208),

characterised in that the method comprises

- providing at least one camera (107) for providing an image (202) of said series of feeder slots,

- performing image analysis (205) on said image for determining (210) the actual feeder IDs (203) of the actually installed feeders in said series of feeder slots,

- for each actual feeder, determining from stored configuration information the first component ID (204') for the type of components contained in said actual feeder, where said stored configuration information comprises a first list (201) associating each intended feeder ID with a component ID (204') indicative of the type of component to be contained in the corresponding feeder (203),

- for each slot (208) defined to contain a feeder, determining from stored configuration information the second component ID (204) for the component that is supposed to be contained in a feeder (104) in said slot (103), where said stored configuration information comprises a second list (207) associating feeder slots with component IDs,

- checking (213) whether the first (204') and the second component ID (204) are equal, and if this is not the case, indicating (209) this discrepancy.

5. Method according to any one of the claims 2 - 4, wherein the slot distance between adjacent slots in said series of feeder slots is constant and wherein said associating position coordinates to the slot ID of each feeder slot comprises
- determining for each particular feeder slot the number of slots from the first slot to the particular feeder slot,
- adding to the position coordinate of the first slot coordinates equivalent to the distance from the first slot to the particular feeder slot, where this distance is calculated as the slot distance between adjacent slots times the number of slots from the first slot to the particular feeder slot.

6. Method according to any one of the claims 2 - 5, wherein said associating position coordinates to the slot ID comprises providing a position mark (111) with a certain fixed distance to said series of feeder slots, imaging said position mark together with said series of feeder slots, and calculating the position coordinates in relation to said position mark.

7. Method according to any one of the claims 2 - 5, wherein said series of feeder slots are mounted on a displaceable table (102) with a rest position or start position, wherein said associating position coordinates to the slot ID is performed using an image taken in the rest position or start position of said table (102).

8. Method according to any one of the preceding claims, wherein the placement machine (101) is of the type where splicing is applicable, wherein the method comprises image recognition of a label at the splicing region of the component reel in a feeder (104) and storing the data and time for the use of components from a spliced reel.

9. Method according to any one of the preceding claims, wherein the obtained image is analyzed for recognition of components from a feeder and for determination,

whether the components from a feeder in a feeder slot corresponds to components intended to be taken from that feeder.

10. Method according to any one of the preceding claims, wherein the obtained image is analyzed for recognition of the reel pitch.

ABSTRACT

Feeder verification with a camera

Method for component verification during operation of a component placement machine (101) having a series of feeder slots (103) for holding component feeders (104) with feeder markers, each feeder marker carrying a unique feeder ID, wherein each feeder slot (103) has a unique slot ID (208). On an image taken with a camera of the feeder slots, image analysis is performed to check whether the actual feeders in the slots corresponds to those feeders that are intended to be placed in these slots.

(FIG. 1)

1/3

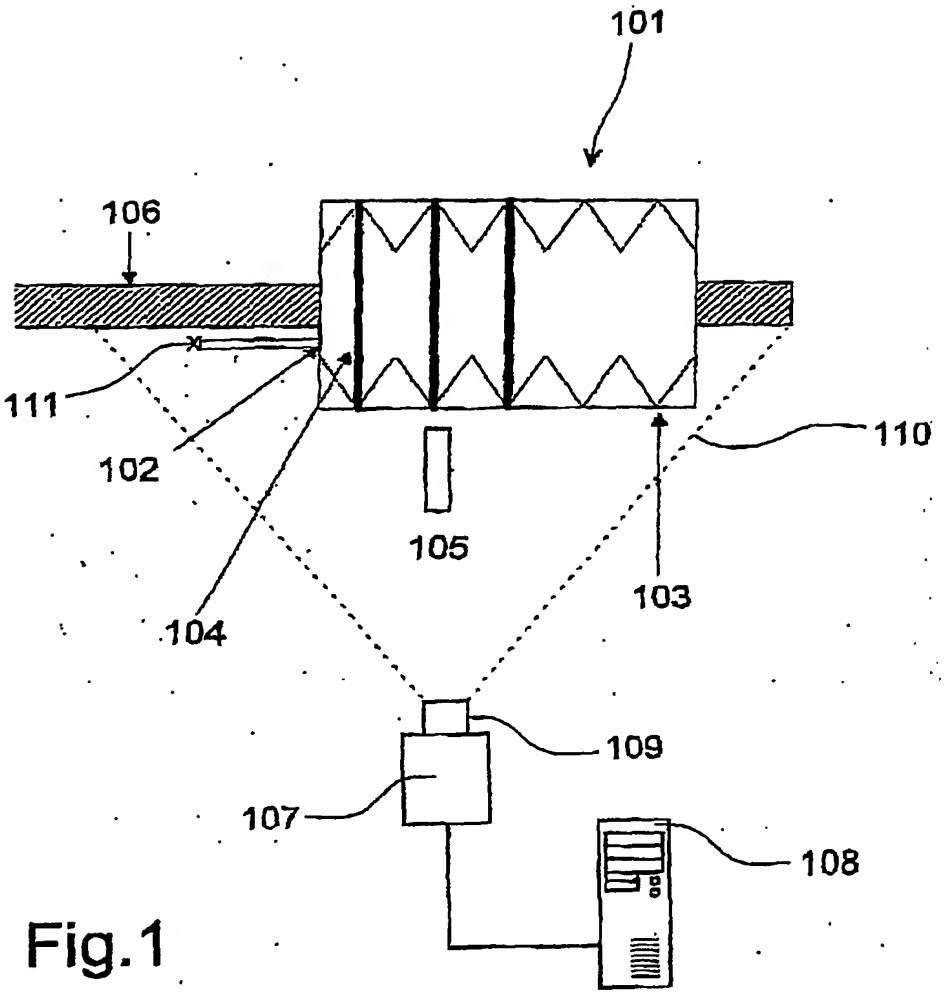

Fig.1

2/3

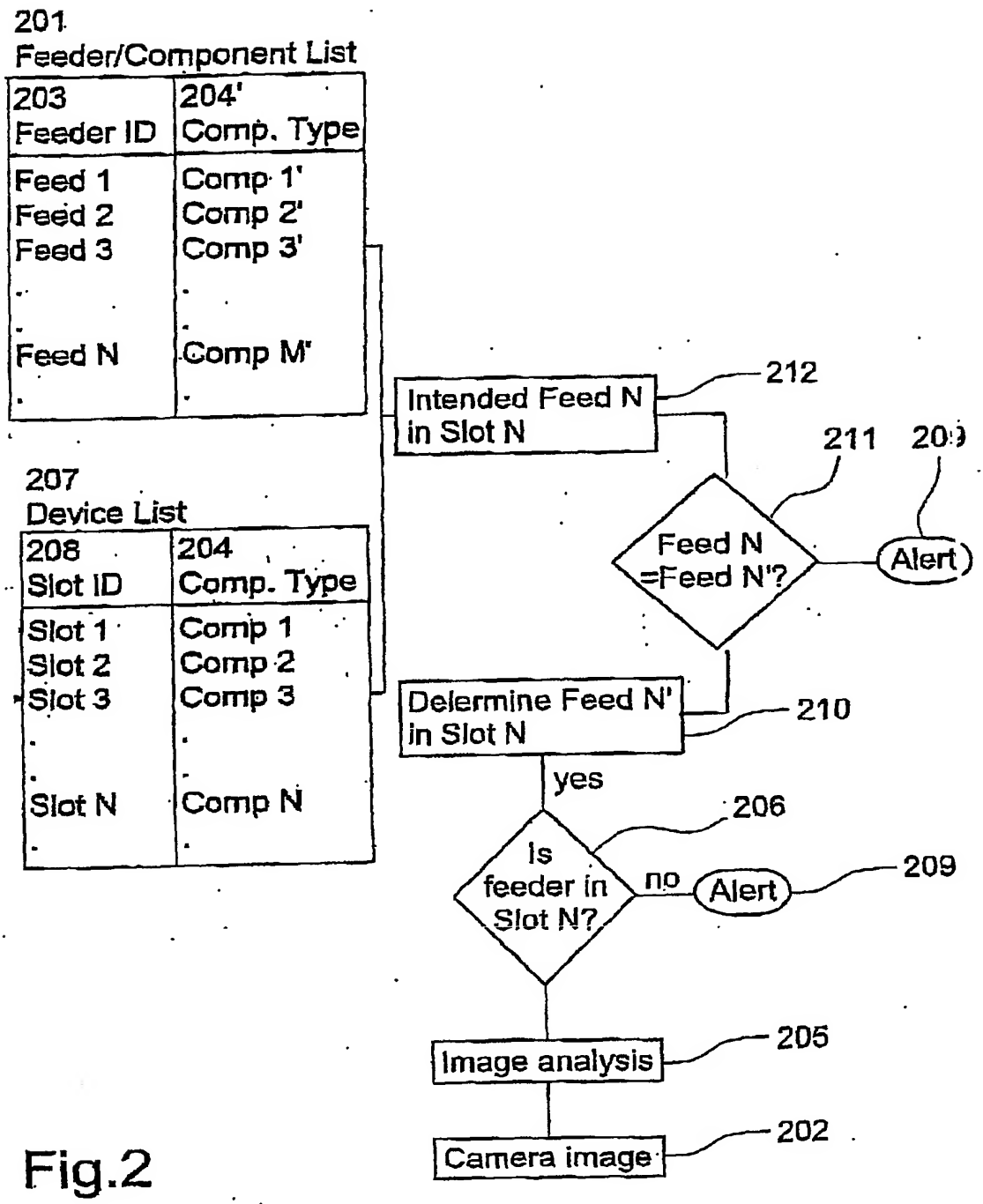
201
Feeder/Component List
203 Feeder ID
204' Comp. Type
Feed 1
Feed 2
Feed 3
Feed N
Comp 1'
Comp 2'
Comp 3'
Comp M'
207
Device List
208 Slot ID
204 Comp. Type
Slot 1
Slot 2
Slot 3
Slot N
Comp 1
Comp 2
Comp 3
Comp N
Intended Feed N in Slot N
212
211
Feed N =Feed N'?
Alert
Delermine Feed N' in Slot N
210
yes
206
Is feeder in Slot N?
no
Alert
209
Image analysis
205
Camera image
202

Fig.2

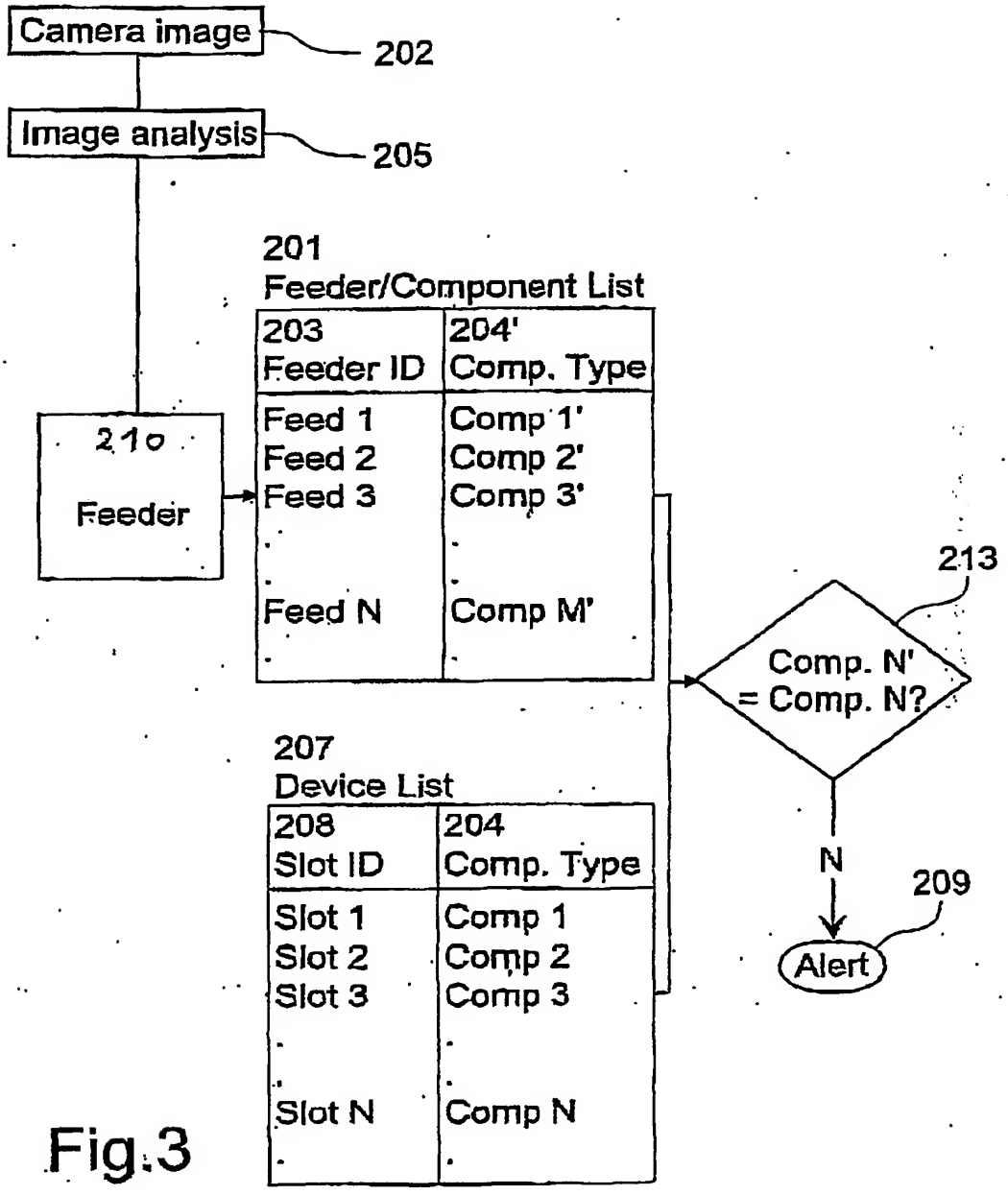
Camera image
202
Image analysis
205
201
Feeder/Component List
203
Feeder ID
204'
Comp. Type
Feed 1
Feed 2
Feed 3
Feed N
Comp 1'
Comp 2'
Comp 3'
Comp M'
210
Feeder
213
Comp. N'
= Comp. N?
207
Device List
208
Slot ID
204
Comp. Type
Slot 1
Slot 2
Slot 3
Slot N
Comp 1
Comp 2
Comp 3
Comp N
N
209
Alert

Fig.3